Structural Style and Kinematic Evolution of the Central Rocky Mountain Foothills, British Columbia and Alberta

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Summary

The change in structural style of the Canadian Rocky Mountain Thrust and Fold Belt from thrust-dominated in the south to fold-dominated in the north reflects a northward decrease in the overall competency of the deformed stratigraphic section. The transition in structural styles occurs over a broad area between Athabasca River (53°15' N) and Peace River (56° N). This study focuses on the transitional, central segment of the Canadian Rocky Mountain Foothills in the region straddling the BC-Alberta border (Fig. 1). In this area the exposed Foothills form a fold-dominated, fold and thrust belt. In the east, deformation at surface dies out eastward over a broad zone, and subtle folds commonly mark its eastern limit. In the west, the boundary with the Rocky Mountains structural subprovince varies from a well defined thrust with significant stratigraphic separation to a detachment zone in Jurassic shales formed above plunging folds in Paleozoic and Triassic strata.

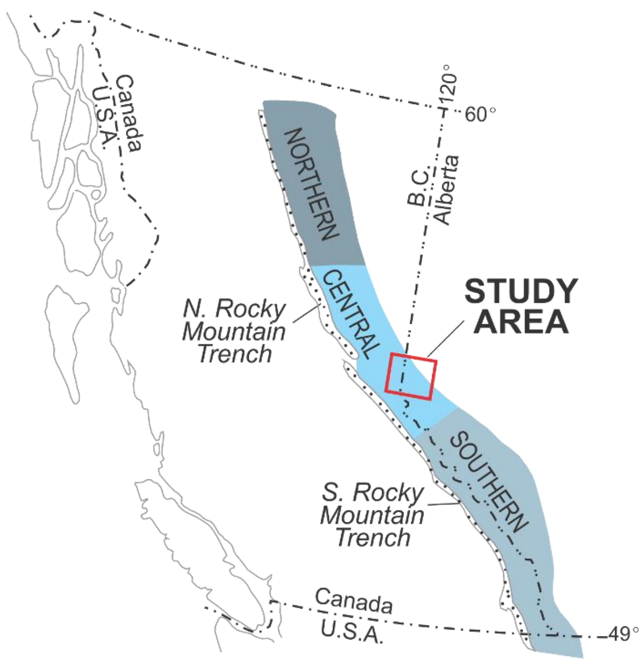

Figure 1. Location of the study area in relation to the major subdivisions of the Rocky Mountain Fold and Thrust Belt.

Exposed Foothills folds are chevron or box folds with relatively straight limbs and narrow hinge areas. Marked changes in fold wavelength, amplitude, and geometry from one relatively competent stratigraphic level to another indicate that several detachment horizons in the Jurassic-Cretaceous section were at least locally utilized. Thrust faults are an important structural element in the exposed fold belt. Most thrust faults trend northwest, subparallel to the folds in their footwalls and hanging walls. Considerable variation in the local kinematic relationships between faulting and folding has occurred (Fig. 2). Some northeast-directed thrust faults are folded congruently with the underlying detachment folds, implying that movement on these faults predated the development of those footwall folds, and in many cases predated detachment folding in their hanging walls. Other thrust faults disappear into fault tip folds or trains of folds, and several thrust faults show a decrease in stratigraphic separation along strike as nearby folds in either the hanging wall or footwall increase in amplitude. These relationships indicate fault-to-fold displacement transfer and a more or less concurrent time of formation. Thrust faults that are partially folded by footwall folds occur and indicate movement relatively late in the folding process (Fig. 3). Thrust faults that truncate at high angle both hanging wall and footwall strata on the steep limb of a fold, or form the faulted core of a fold are relatively common. Such faults are thought to propagate through an existing fold during the late stages of fold tightening or after the fold became locked ("break-thrusts" of Willis and Willis, 1934 (p. 177); see also Dixon and Tirrul, 1991; and Mitra, 2002). A few thrust faults clearly truncate or decapitate both limbs of a fold or a series of folds in either their footwalls or hanging walls and therefore postdate fold development.

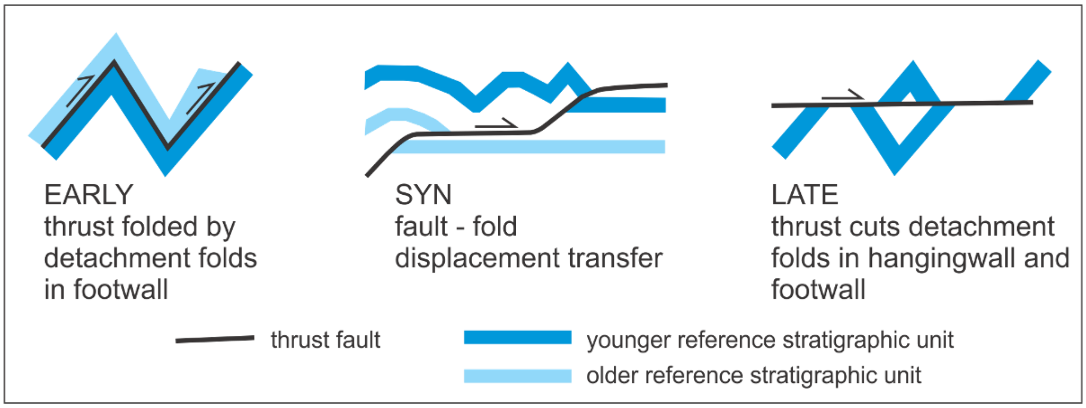

Figure 2. Schematic diagrams illustrating the variety of kinematic relationships between thrust faults and folds observed in the Foothills in the study area.

The exposed faulted fold belt developed in Jurassic and Cretaceous strata conceals an underlying thrust belt in Triassic and older strata characterized by smaller displacement (< 3 km at top of Triassic) thrust faults. Geometric relationships within this thrust belt interpreted from seismic, well, and surface data indicate thrust belt deformation progressed from west to east consistent with the timing of uplift indicated by vitrinite reflectance data (Kalkreuth and McMechan, 1984) and the pattern of deformation in the Rocky Mountains to the west. Only one thrust fault, the Muskeg Thrust that separates the inner and the outer Foothills, has significant out-of-sequence motion.

Figure 3. Davey Creek Anticline and the partially folded Mount Russell Thrust (dotted line) at Davey Creek 10 km southwest of Grande Cache, Alberta. View to northwest.

Displacement on thrust faults cutting Triassic and older strata fed upward and eastward into detachments in the Jurassic and Cretaceous section. The level of detachment initially utilized by each thrust fault had an important effect on the local structural style and kinematic history of the overlying faulted fold belt. In the inner Foothills some thrust faults cut through the stratigraphic section from the Triassic to the highest level of detachment and extend directly to surface. Other thrust faults fed into detachment zones at intermediate stratigraphic levels (Fernie, Gorman Creek, Shaftesbury), and usually resulted in significant detachment folding and fault-to-fold displacement transfer. In the outer Foothills thrust faults cutting the Triassic fed into a series of tectonic wedges bounded by roof and floor thrusts with opposing movement directions. Sequential deformation of balanced cross-sections shows that the complicated, local kinematic relationships observed in the Foothills result from the changing levels of active detachment surfaces as the thrust and fold belt developed.

References

Dixon, J.M., and Tirrul, R., 1991, Centrifuge modelling of fold-thrust structures in a tripartite stratigraphic succession: Journal of Structural Geology, **13,** no. 1, 3-20.

Kalkreuth, W. ,and McMechan, M.,1984, Regional pattern of thermal maturation as determined from coal rank studies, Rocky Mountain Foothills and Front Ranges north of Grande Cache, Alberta - implications for petroleum exploration: Bulletin of Canadian Petroleum Geology, **32**, 249-271.

Mitra, S., 2002, Fold-accommodation faults: AAPG Bulletin, **86**, no. 4, 671-693.

Willis, B., and Willis, R., 1934. Geologic Structures. McGraw-Hill Book Company, 3rd ed., 544 p.